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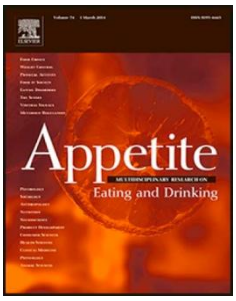

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Appetite

Manipulations of attention during eating and their effects on later snack intake

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Running header: attention, memory and food intake

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Highlights

- Distraction during eating increased later snacking and reduced meal memory
- The effect of distraction was larger when motivation to engage with the distracter was greater
- The effect of distraction was offset when the distractor included food-related cues
- Focusing attention during eating decreased later snacking

Abstract: Manipulation of attention during eating has been reported to affect later consumption via changes in meal memory. The aim of the present studies was to examine the robustness of these effects and investigate moderating factors. Across three studies, attention to eating was manipulated via distraction (via a computer game or TV watching) or focusing of attention to eating and effects on subsequent snack consumption and meal memory were assessed. The participants were predominantly lean, young women students and the designs were between-subjects. Distraction increased later snack intake and this effect was larger when participants were more motivated to engage with the distracter and were offset when the distractor included food-related cues. Attention to eating reduced later snacking and this effect was larger when participants imagined eating from their own perspective than when they imagined eating from a third person perspective. Meal memory was impaired after distraction but focusing on eating did not affect later meal memory, possibly explained by ceiling effects for the memory measure. The pattern of results suggests that attention manipulations during eating have robust effects on later eating and the effect sizes are medium to large. The data are consistent with previous reports and add to the literature by suggesting that type of attention manipulation is important in determining effects on later eating. The results further suggest that attentive eating may be a useful target in interventions to help with appetite control.

INTRODUCTION

It is increasingly being recognised that memory for recent eating plays an important role in appetite (Higgs 2002; Higgs et al. 2012; Martin and Davidson 2014; Brunstrom 2014). Indeed, the flexibility of human eating behaviour may be underpinned by our ability to use information about past eating events to inform future eating behaviour. It has been reported that manipulating memories for recent eating affects future consumption decisions (for reviews see Higgs 2005; 2008). For example, boosting memories of recent eating via explicit recall of the last meal reduces food intake (Higgs 2002; Higgs, Williamson and Attwood, 2008a). On the other hand, amnesic patients, who are unable to remember eating, eat multiple meals in quick succession (Hebben et al. 1895; Rozin et al. 1999; Higgs et al. 2008b). Furthermore, inducing a false memory of what has been eaten has been found to influence appetite in the inter-meal interval (Brunstrom et al. 2012). In line with the view that an important function of memory is to be able to more reliably predict the future by utilising past experience, these results suggest that memories formed during

eating are factored into to future decisions about when and how much to eat, probably because they allow for efficient prediction about whether consumption of food is likely to be rewarding (Higgs 2015; Martin and Davidson 2014).

There have been several investigations of how manipulation of the attention paid to food as it is eaten affects later consumption via changes in meal memory. If attention is drawn away from eating by providing participants with the opportunity to watch television or play a computer game while eating, these distracted participants will eat more later than participants who were not distracted during eating (Higgs and Woodward, 2009; Mittal et al. 2011; Brunstrom et al. 2011). Conversely, if participants are encouraged to focus on food while they are eating then they will eat less than participants who were asked to eat as usual (Higgs and Donohoe 2011; Robinson et al. 2014). Importantly, these effects of distraction or attentive eating on snack intake are observed even though all participants consume the same lunch meal. The effects are also observed in the absence of effects of the attention manipulation on rated mood or hunger or eating rate. Moreover, the evidence suggests that the effects are related specifically to changes in measures of meal memory.

While the effects of manipulating attention paid to eating on later intake appear to be robust (Robinson et al. 2013a), there has been little investigation of the factors that may moderate these effects. The aim of the studies presented here was to replicate the basic effects and examine 1) whether the amount of attention paid to eating affects later consumption and 2) whether the type of attention manipulation alters the size of the effect. In Study, 1 the level of distraction away from eating was manipulated by providing an incentive to play a computer game while eating. It was hypothesised that

paying participants would increase the amount of attention paid to playing the game and hence reduce the amount of attention paid to eating. It was further hypothesised that participants who were paid to play the game would show a larger increase in later snacking than participants who were not paid to play the game (or who were not distracted by a game). In Study 2, the type of TV programme watched during eating was manipulated. Participants either watched a programme that contained no reference to eating, or they watched a food-related programme that involved preparation of a food similar to that being eaten. It was hypothesised that the non-food-related distractor would have a greater effect to increase later intake than the food-related distractor. It was reasoned that the presence of the food being consumed in the TV programme might act as cue to trigger thoughts and images of the food being eaten which would offset somewhat the generally distracting effects of TV watching. Hence, it was hypothesised that the overall effect of watching food-related TV would be intermediate between the effects watching non-related TV and not watching any TV programme. Finally, the effect of attentive eating on later snacking was examined and we manipulated whether the participants focused on the meal from their own perspective or from the perspective of another person. Here, it was hypothesised that there would be a greater effect of attentive eating to reduce later consumption when participants were asked to imagine themselves eating the meal versus when they were asked to imagine someone else (a celebrity) eating the meal. This was because of evidence that self-referential thinking leads to enhanced memory and imagining an event from a personal perspective makes that event particularly memorable (Grilli & Glisky 2010; Symons, & Johnson, 1997).

Methods

Study 1

Participants

The participants were 39 normal weight young women students (mean age = 20, standard deviation (SD) 1.7 years, mean BMI = 22, SD 2.4) from the School of Psychology, University of Birmingham, who took part in the study in return for course credits. We restricted our sample to women only because males tend to take advantage of the opportunity to eat as much as possible in these kinds of studies and it is hard to recruit enough men from a predominantly female cohort of students (Mittal et al., 2011). Eating habits were assessed by the Dutch Eating Behavior Questionnaire (DEBQ, (Van Strien et al., 1986). Scores for emotional eating (mean = 2.6, SD = 1.0), restrained eating (mean = 2.7, SD = 0.9) and external eating (mean = 3.4, SD = 0.5) were within the normal range. The sample comprised the first 39 volunteers who met the study's requirements. So that participants were not alerted to the specific purpose of the experiment, recruitment to the study was via an advertisement describing the experiment as a study of meal environments on subsequent food taste preferences. Participants gave informed written consent and the study protocol was approved by the University Research Ethics Committee and conducted according to the ethical standards laid down in the Declaration of Helsinki 1964.

Experimental design

Participants were randomly assigned to one of three experimental conditions: the high distraction group where the participants were told a monetary reward was available for the most wins in the game that week, a low distraction group where the

participants were instructed to play the game without an incentive and a control group where participants ate their lunch with no game as a distraction.

Test foods

Lunch. The lunch consumed by the participants was the same in all conditions. Participants were asked to consume a fixed lunch of several food items presented in a fixed order (see Table 1 for the foods and order of presentation). The reason for this was so that the order of consumption of the lunch items could be tested for recall later. The lunch contained approximately 400 calories. 300 ml of still mineral water was also provided.

Afternoon snack. Three plates of cookies were provided. The cookies were: Sainsbury's Basics (Sainsbury's, UK) chocolate chip cookies (496 calories per 100g), custard creams (496 calories per 100g) and nice biscuits (485 calories per 100g). Approximately 80 g of each cookie type was presented on a separate plate for each cookie type and the cookies were broken into bite size pieces to reduce the likelihood that participant would keep count of the number of cookies consumed. 300 ml of still mineral water was provided

Computer game.

The computer game used in the distraction conditions was an online helicopter game requiring the participants to fly a helicopter and dodge obstacles in a tunnel just using the left mouse button (http://www.helicoptergame.net/). This allowed them to eat the lunch with their other hand.

Procedure

Each test day comprised two sessions: the first session took place between 12.00 and 1.30 p.m and the second between 1.30 and 3.00 p.m. Upon arrival for the first test session (the lunch session), the participant was seated individually at a table in a quiet room and asked to complete a series of line rating scales assessing mood and appetite. The following items were rated using a 100 mm unmarked line rating scale with "Not at all" and "Extremely" as end anchors and the question "How XXX do you feel right now?": hungry, full, bloated, relaxed, irritable, alert, happy and sad (centred above the line). Ratings were obtained by measuring the distance in mm from the left extremity of the lines. Before the lunch the participants in the high distraction condition were reminded of the monetary reward available to the person with the most wins that week. Participants in the low distraction condition were told to play the computer game for the duration of the lunch session. Participants in the no distraction group received no instructions. Participants were asked to consume all of the food provided. They had access to water 300ml, which they could drink ad libitum. Participants in the distraction conditions began playing the computer game and started the first item of an eight item lunch. They proceeded to play the computer whilst eating each food item during 90 second intervals in the order specified. A timer signalled each 90 second interval. Each food item was enclosed in a container with a number on the cover. The participants were instructed to eat the food in numerical order. Pilot testing confirmed that each food item could be consumed in the 90 second interval. The total lunch duration was 15 minutes. Once the lunch had been consumed the same set of rating scales were completed. Participants in the two distraction conditions completed an additional rating scale asking "how motivated were you towards the computer task?". The scale was anchored by "not at all" and "extremely" on a 100-mm line.

This was used as a manipulation check to assess whether there was a difference between the distraction groups in level of motivation towards the computer task. The participants were instructed not to consume any food in between the lunch time session and the snack tasting session and to return in an hour.

At the beginning of the second test session (the tasting session), the participant was asked to rate her appetite and mood using the line rating scales described previously. The participant was instructed to taste and rate each type of biscuit in order of letter type using the sheets provided. Each sheet consisted of scales assessing nuttiness, sweetness, liking and choice. In line with the cover story participants were encouraged to take their time tasting each biscuit, eating as much or as little as they wanted. They were instructed to clear their mouth as fully as possible before moving on to the other variety of biscuit. On the experimenter's return, a final set of scales were completed assessing mood hunger, thirst, fullness and desire to eat. The participants then recalled the serial order of the lunch items. Participants were also then asked to rate how vividly they could remember the lunch that they ate earlier using a 100 mm line rating scale anchored "not at all vividly" and "extremely vividly". At the end of the second test day, participants were asked to write down their thoughts on the aim of the experiment. Height and weight were measured and the participants then completed the Dutch Eating Behaviour Questionnaire (Van Strien et al., 1986). Each participant was thanked, asked to refrain from discussing the study with other students and told that debriefing would be by e-mail at a later date. The amount of cookies consumed by each participant was calculated by weighing the plates before and after the taste test.

Methods

Study 2

The general methods for Study 2 were similar to those described for Study 1 and so only variations in the methods are described.

Participants

The participants were 63 normal weight young women students (mean age=19.7 years, SD = 3.5 years, BMI =22.1, SD=3.4*)* from the School of Psychology, University of Birmingham. The experiment was advertised as a study about mood and eating.

Experimental Design

A between-subjects design was used and participants were randomly allocated to one of three lunch conditions: watching a food-related TV clip (TV food condition), watching a non-food-related TV clip (TV condition) or watching no TV at all (control condition).

Tests Foods

Lunch Session

The same lunch was consumed by all participants. It consisted of one 300g tin of Heinz Cream of Tomato Soup (171 kcal) heated to 71°C and one slice of Kingsmill 50/50 Medium Sliced Bread from an 800g bag cut into eighths (94 kcal). 200ml of tap water was provided.

Snack Session

Three types of biscuits were provided for participants to taste. 100g each of McVities chocolate digestives (495 kcal per 100g), Cadbury's milk chocolate fingers (520 kcal per 100g) and Maryland chocolate chip cookies (487 kcal per 100g).

TV clips

The TV clip was a video of Jamie Oliver making tomato soup, 'Oliver's Twist' (http://www.tubechop.com/watch/1850690) lasting 8 minutes 16 seconds. A clip from 'Homes Under the Hammer' (http://www.youtube.com/watch?v=MgstQLDkaQk) lasting 8 minutes 24 seconds was rated most similar to 'Oliver's Twist' in in terms of how interesting, funny and entertaining it was in a pilot study and so was chosen as the non-food TV clip.

Procedure

The experiment comprised two sessions both lasting 30 minutes. The lunch session took place between 12:00 and 2:30pm and the snack session between 2:30 and 5:30pm. Participants were asked to refrain from eating for at least two hours before the first session. After arriving for the lunch session, participants were seated alone in a quiet room and asked to complete mood and appetite rating scales. Participants were then given lunch and had nine minutes to eat it whilst watching either a food-related TV clip, a non-food-related TV clip or not watching TV. All participants were asked to finish the lunch and those watching TV were told to pay close attention to the clip because they would later be asked some questions about it. After finishing the lunch, participants completed the mood and appetite scales again. They also completed scales to assess their liking for the lunch which asked, 'How much did you like the lunch you ate?' and 'How much would you like to eat this type of food again?

Participants in the TV conditions then answered a quiz designed to assess whether they had watched the TV clip and were sufficiently distracted by it. Before leaving, participants were reminded to attend the afternoon snack session, scheduled for 2.5 hours later that day and were asked to refrain from eating before the second session. Upon arrival at the snack session, participants completed the mood and appetite rating scales again. They then took part in a taste test; they were presented with three types of chocolate biscuits and to encourage consumption, they were informed that they could eat as many as they wished as they had to be thrown away after their participation (Higgs & Woodward, 2009). Participants were left for 10 minutes to rate the biscuits for how crunchy, sweet, nutty and salty the biscuits were and how much they liked their taste and texture. They completed a rating scale which asked, 'How vivid is your memory of the lunch?'. Participants' eating habits were then assessed by the restraint subscale of the DEBQ and the disinhibition subscale of the Three-Factor Eating Questionnaire (TFEQ) (Stunkard & Messick, 1985). Participants' height and weight were then measured to calculate BMI. Participants were then asked to write down what they thought the study was about. They were then debriefed, asked to refrain from discussing the study with their peers and thanked for their participation.

Study 3

The general methods for Study 3 were similar to those described for Study 1 and 2 and so only variations in the methods are described.

Participants

45 undergraduate students took part in the study (38 females and 7 males). The mean age of participants was 19 years (SD= 0.97), with a mean BMI of 21.9 (SD= 3.16).

The mean dietary restraint score (DEBQ) was 2.0 (SD= 0.79) and the mean tendency towards disinhibition (TFEQ) score was 6.3 (SD= 2.81).

Design

The study had a between-subjects design and there were three conditions: 1) a self-imagining condition, in which participants were instructed via an audio clip to imagine they were watching themselves eat 2) an imagining-celebrity condition, in which participants were instructed, again via an audio clip, to imagine they were watching a celebrity (David Beckham) eat, and 3) a control condition, who were just instructed to eat their lunch without a manipulation.

Materials

Audio clips

There were two different audio clips used in this study. Both were approximately three minutes long. Both clips involved instructing the participant to imagine they were an observer. For participants in the self-imagining condition, the clip asked them to imagine they were able to watch themselves eat in the room, whilst for participants in the imagining-other condition the clip asked them to imagine they were watching David Beckham eat in the room. Celebrity imagery was used as it has been found that imagining a close other has the same effect as self-imagining (Hamami, Serbun & Gutchess, 2011), so by using a celebrity image this should be more distant to the self. The clip started with instructing the participant to imagine they are able to watch either them self or David Beckham in the room they are sitting in and asks the participant to make a clear image in their head of their surroundings. The clip then moves on to instructing them to imagine they are able to watch either them self or

David Beckham eat the lunch. The clip is said in a neutral tone and is said slowly with several pauses to allow the participant to imagine the scene.

Lunch

A lunch consisting of 8 items was given to each participant. The foods given are shown in Table 2.

Each food item was enclosed in an airtight container with a number on the top. All participants were given the same set lunch to eat, and these lunch items were given in the same order each time. 300ml of still water was also provided in a glass to all participants.

Afternoon snack

For the afternoon snack session three different biscuits were used: McVitie's digestives (McVities & Price Ltd, Edinburgh, UK, 495 calories per 100g), Maryland chocolate chip cookies (Burton's food Ltd., Merseyside, UK, 511 calories per 100g), and Cadbury's milk chocolate fingers (Burton's food Ltd., Merseyside, UK, 520 calories per 100g). Each type of biscuit was placed in a different glass bowl, with approximately 60g of each cookie type being used.

Procedure

Participants attended two sessions which both took part in the same day. The first session took place between 12-2pm and the second session took place approximately two hours later between 2-4pm. Each session lasted approximately 20 minutes. Participants were instructed not to eat for two hours before the study. In the first session, participants were then seated and baseline measurements of appetite and

mood were taken. Participants then ate a fixed lunch consisting of eight items. All participants ate these in the same order. Participants were left alone for ten minutes while eating the lunch. For the self-imagining and imagining-other conditions, participants listened to a three minute audio clip through headphones which instructed them to either imagine they were watching themselves eat or a celebrity eat, respectively. Participants in the control condition had their lunch in silence. Participants then completed the appetite and mood scales again. Participants were then able to leave the lab and were instructed not to eat during the break between the two sessions. On their return in the second session, participants then completed the appetite and mood scales. Participants were then given the three plates of cookies and were left for ten minutes to taste the cookies and rate them on some visual analogue scales. Before being left alone, participants were told to eat as many cookies as they liked as the cookies would be thrown away afterwards. After the ten minutes had passed, participants filled out another appetite and mood scale. They then were asked to rate the vividness of their memory for the lunch they had earlier and were instructed to write down the order in which they ate it. They were also told to write down briefly what they believed about the purpose of the study. Finally, participants' completed the DEBQ and TFEQ and their height and weight were then measured and they were thanked for their participation and were told that they would be debriefed by e-mail.

Analyses

Since the effects of attention during eating on later intake has been reported previously our aim was to provide a further test of the reliability of the effects and to investigate whether the effect size differs according to variation in the type of

attention manipulation. In keeping with the new approach to statistics and to aid future meta-analyses we report estimates and effect sizes for the main results of interest (Cummings 2013).

RESULTS

Study 1

Participant characteristics

Table 3 shows the characteristics of the sample for Study 1. All participants were young women in the normal BMI range.

Biscuit intake

Intake was highest in the high distraction condition (mean = 36.2 g; 95% confidence interval (CI) = [26.8,45.6]), and lowest in the control condition (mean = 21.4 g 95% confidence interval (CI) = [12,30.8]). Intake for the low distraction group was in between the two other conditions (mean = 29.8 g 95% confidence interval (CI) = [20.3,39.2]. The effect size for the comparison between the control and high distraction condition was large Cohen's d = 0.87 and the effect size for the comparison between the low distraction condition and the control condition was medium Cohen's d = 0.6. See Figure 1a.

Memory measures

For the memory recall, serial order accuracy was highest in the control condition (mean = 7.3/8 items 95% confidence interval (CI) = [6.4,8.3], and lowest in the high distraction condition (mean = 5.6/8 items, 95% confidence interval (CI) = [4.6,6.5], with the low distraction condition intake being in between the two (mean = 7.1/9 items, 95% confidence interval (CI) = [6.1,8.1]. The effect size for the comparison

between the control and high distraction condition was large Cohen's d = 1.1 and the effect size for the comparison between the low distraction condition and the control condition was medium Cohen's d = 0.6.

Memory vividness ratings were highest in the control condition (mean = 80, 95% confidence interval (CI) = [67,92], and lowest in the high distraction condition (mean = 61, 95% confidence interval (CI) = [49,74], with the low distraction condition ratings being in between the two (mean = 66, 95% confidence interval (CI) = [54,79]. The effect size for the comparison between the control and high distraction condition was large Cohen's d = 1 and the effect size for the comparison between the low distraction condition and the control condition was medium Cohen's d = 0.6.

Manipulation check and confounders: the motivation rating was higher in the high distraction group (mean = 7.3, 95% confidence interval (CI) = [6.4,8.1] than the low distraction group (mean = 6.2, 95% confidence interval (CI) = [5.4,7.1] and this contrast was a medium effect size Cohen's d = 0.7. No participants guessed the aim of the study and mood ratings did not differ between groups.

Study 2

Participant characteristics

Table 4 shows the characteristics of the sample for Study 2. All participants were young women in the normal BMI range.

Biscuit intake

Intake was highest in the TV condition (mean = 82.8g; 95% confidence interval (CI) = [65.8,99.8]), and lowest in the control condition (mean = 67.4g, 95% confidence interval (CI) = [50.3,84.5]). The food TV condition intake was in between the two other conditions (mean = 74.7g 95% confidence interval (CI) = [57.7,91.8]. The effect size for comparison between the control and TV condition was small Cohen's d = 0.4 and the effect size for the comparison between the food TV condition and the control condition was small Cohen's d = 0.2. See Figure 1b.

Memory measures

Memory vividness ratings were highest in the control condition (mean = 69.4, 95% confidence interval (CI) = [62,77], and lowest in the TV condition (mean = 62, 95% confidence interval (CI) = [54,69], with the food TV condition intake being in between the two (mean = 63, 95% confidence interval (CI) = [55,71]. The effect sizes were medium for both the high and low distraction conditions compared with the control but smaller in the food TV condition: Cohen's d = 0.5 and 0.4 respectively.

Manipulation check and confounders: Both the TV groups had similar scores on the questionnaire about the content of the TV programmes, suggesting that they were equally distracting while differing in the specific content. Mean score for the food TV group was 3 out of 5 correct 95% confidence interval (CI) = [2.7,3.5] and mean scores for the TV group was 3 out of 5 correct 95% confidence interval (CI) = [2.7,3.5]. No participants guessed the aim of the study and mood ratings did not differ between groups.

Study 3

Participant characteristics

The sample was predominantly young women in the normal BMI range (See Table 5). A few male participants were also tested but they were not analysed separately due to the small numbers. The pattern of results was similar for males and females and so the overall means and effect sizes are presented.

Biscuit intake

Intake was highest in the control condition (mean = 80g, 95% confidence interval (CI) = [66.2,93.8]), and lowest in the self-imagining condition (mean = 56g, 95% confidence interval (CI) = [42.2,69.8]). The celebrity-imagining condition intake was in between the two other conditions (mean = 62.5g, 95% confidence interval (CI) = [48.7,76.3]. The effect size for the comparison between the control and self-imagining condition was large Cohen's d = 0.9 and the effect size for the comparison between the celebrity-imagining condition and the control condition was medium Cohen's d = 0.6. See Figure 1c.

Memory measures

For the memory recall, accuracy was similar in all conditions and was close to ceiling (mean control condition = 7.6/8 items 95% confidence interval (CI) = [7.1,8], mean celebrity-imagining condition = 7.6/8 items, 95% confidence interval (CI) = [7.1,8.0], mean self-imagining condition = 7.6/9 items, 95% confidence interval (CI) = [7.2,8]. The effect sizes were negligible.

Memory vividness ratings were lowest in the celebrity-imagining condition (mean = 76.5, 95% confidence interval (CI) = [68.6,84.4] but similar in the self-imagining condition (mean = 80.6, 95% confidence interval (CI) = [72.7,88.6], and control condition (mean = 82.5, 95% confidence interval (CI) = [74.6,90.4]. The contrast between the control and celebrity-imagining condition was medium, Cohen's d = 0.5 and the contrast between the control and self-imagining condition was small, Cohen's d 0.1.

DISCUSSION

In three studies, attention paid to food while it was being eaten was manipulated and the effects on later intake and meal memory were assessed. Despite differences in the type of lunch eaten (e.g. buffet versus soup) and the type of attention manipulation (e.g. computer game playing versus TV watching), a clear pattern of results was observed. Distraction during eating increased later snack intake while focusing on

487 food decreased later snack intake. These effects were large and are consistent with
488 previous reports (Higgs and Woodward, 2009; Higgs and Donohoe 2011; Brunstrom
489 et al. 2011; Mittal et al 2011; Robinson et al. 2014). Distraction during eating
490 impaired later meal memory whether it was assessed by serial recall of the order in
491 which foods were eaten or a measure of meal memory vividness. However, enhancing
492 attention towards food was not associated with better meal memory as assessed by a
493 rating of memory vividness.
494
495 In Study 1, the effects of distraction during eating were enhanced if there was an
496 incentive to engage with the distracting computer game. There was also a greater
497 effect on meal memory in the incentivized condition than in the non-incentivized
498 condition. These data suggest that greater motivation to engage with the computer
499 game reduced attention paid to the meal, which may have resulted in greater later
500 intake and poorer meal memory. The effect sizes for intake and meal memory were
501 both large, which supports the suggestion that changes in memory processes underlie
502 the effects of distraction on later eating.
503
504 In Study 2, the distracting effects of TV were offset somewhat when the TV
505 programme contained images of the food being consumed by the participants. One
506 reason for this may be that the food images provided a cue to the participants to focus
507 on their own meal by prompting thoughts and images of the food being eaten, which
508 reduced the impact of TV watching on meal encoding. These data suggest that the
509 content of a distracting TV progamme may influence meal memory encoding. Mittal
510 et al. (2011) did not find differential effects of watching a boring, sad or funny TV
511 programme on later intake. It may be that the mood inducing effects of TV do not

affect later intake, but other content related factors, such as the presence or absence of food, are influential. In line with this suggestion, Higgs and Donohoe (2011) reported that reading a newspaper article about food during lunch did not increase later snack intake relative to a no distraction control condition. It may be that the presence of food-related cues during distraction is sufficient to keep the participants interested enough in their own eating to offset the effects of distraction on memory. In order to test whether the effects observed in Study 2 are specifically related to the participants paying more attention to the food they were consuming in the food-TV condition, it will be necessary to examine whether watching a TV programme about food generally, and not just the food being eaten, has similar effects.

In Study 3, we replicated the previously reported finding that focusing on food while eating reduces later snack intake (Higgs and Donohoe 2011; Robinson et al. 2014). Participants who were instructed via audio clip to imagine themselves eating the meal ate fewer snacks later than participant who ate without any such instructions. We further found the effects of imagining eating were reduced if participant imaged eating from a third person perspective. The use of the self-imagination versus other-imagination task is useful because it controls for the general demands of the procedure such as effects on eating rate, hedonic appreciation and demand awareness. It is also a useful manipulation from the point of view of the role of memory in eating because there is evidence that memories are better encoded if event is seen from a personal perspective (Grilli & Glisky 2010; Symons, & Johnson, 1997). One explanation for the present pattern of results is that intake was reduced after lunch because the self-imagining task led to a better meal memory than the celebrity-imagining and control tasks. However, we found no evidence that meal memory was enhanced in either of

537 the imagining conditions. This may be because there were no effects of the
538 manipulation on memory encoding, but perhaps more likely, because there were
539 limitations to the memory measure used that precluded observing significant effects.
540 While decreases in meal memory have been demonstrated consistently, increases in
541 memory have proved harder to observe. For example, Robinson and colleagues (2014)
542 also found no effects of focusing on food while eating on later meal memory, despite
543 observing a reduction in intake. In the Robinson and colleagues study (2014), and the
544 studies here, meal memory in the control condition was near perfect and so it may be
545 that ceiling effects prevented any effects of memory enhancement being detected.
546 This suggests that future research should be directed at developing more sensitive
547 measures that are capable of detecting both decreases and increases in meal memory.
548 In addition, other possible explanations for the effect of "attentive eating" on later
549 intake that do not relate to memory should be explored.
550
551 The experiments presented in this paper suggest consistent and large effects of
552 manipulating attention during eating on later intake. However, there are limitations to
553 the methods that should be discussed to inform future research in the area. First, the
554 samples tested are very homogenous and consist predominantly of young women of
555 normal BMI. This is also true of other similar studies (Higgs and Woodward, 2009;
556 Higgs and Donohoe 2011; Mittal et al. 2011; Brunstrom et al. 2011), although one
557 study has explored the effects of focused attention during eating in overweight women
558 and found similar effects (Robinson et al. 2014). Given the proposed underlying
559 cognitive mechanisms, it seems unlikely that different effects would be observed in a
560 more representative sample, but this should be confirmed in future studies. The effects
561 have also only been observed over a short time frame and so it would be interesting to

562 examine whether there are sustained effects of manipulating attention during eating on
563 cumulative intake over a longer period. In addition, the effects of manipulating
564 attention during eating on later consumption have only been investigated for snacking
565 and it would be interesting to know if later meals are similarly affected. Alternative
566 methods could also be used to provide convergent evidence on the role of attention
567 and memory in appetite control, for example by using ecological momentary
568 assessment to examine relationships between these variables and food intake in a
569 more naturalistic setting.
570
571 The fact that large effects sizes have been observed in these and other studies has
572 implications for theories of appetite control as well as potential practical applications.
573 The data provide further evidence for a role of memory for recent eating in appetite
574 control and emphasize the importance of higher cognitive function in eating behavior
575 (Higgs, 2015). There are also implications for understanding the relations between
576 diet and cognition. There is emerging evidence that Western-type diets can damage
577 brain structures important for learning and memory (Kanoski and Davidson, 2011).
578 These data, together with the evidence that food intake is influenced by processes that
579 recruit memory and attention, suggest that there are bidirectional links between
580 cognition and diet. Consumption of a high-fat, high-sugar diet may have detrimental
581 effects on memory function and appetite control which sets up a vicious cycle to
582 promote overeating (Francis and Stevenson 2011; Davidson et al. 2005). However,
583 the results also suggest that strategies aimed at promoting attentive eating and better
584 memory for recently eaten foods may be helpful in appetite control. The feasibility of
585 using a smartphone app to prompt recall of food consumed recently prior to the next
586 eating occasion was tested recently in a small trial of overweight participants

(Robinson et al. 2013). The results suggested that a randomized controlled trial testing proof of principle for an attentive eating intervention on weight loss is warranted. There are also implications of the present findings for understanding the effects of different types of distractors on eating. Social eating situations are distracting (Hetherington et al. 2006), which may contribute to the social facilitation of eating (Herman, 2015), yet in these situations there are also food related cues present from watching others eat. It would be interesting to assess the effects on meal memory and later intake of social meals in which participants are consuming the same versus different foods to their companions.

In summary, further evidence is provided of the role of attention to eating and memory for recent eating in the control of food intake. The effect of distraction during eating on later consumption is a large effect size that can be offset somewhat by the presence of food-related cues during distraction. Focusing on food during eating can reduce later consumption especially if the focus is on personal consumption. The effects are moderate to large and replicable suggesting that they may provide a firm evidence base for the development of interventions aimed at enhancing appetite control.

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688 Figure 1 – Mean biscuit intake according to condition across Studies 1-3. Error bars
689 are 95% confidence intervals.

690

691 Table 1. Lunch items in presentation order for Study 1

Type of food	Amount (g)	Energy per portion (kcal)
Salt and vinegar crisps	12	66
1/4 slice cheese and tomato sandwich	27	91
Mini sausage roll	16	58
Cherry tomatoes	40	8
1/4 slice Ham sandwich	35	38
Ready salted crisps	12	64
Mini Cornish pasty	24	66
Carrot batons	20	9
TOTAL	186	400

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Table 2: Lunch items in presentation order for Study 3

Type of food	Amount (g)	Energy per portion (kcal)
Salt and vinegar crisps	12	66
¼ slice cheese and tomato sandwich	27	91
Mini sausage roll	16	58
Cherry tomatoes	40	8
¼ slice ham sandwich	35	108
Carrot batons	20	9
Mini Cornish pasty	24	66
Ready salted hula hoops	12	64

Table 3 characteristics of the sample for Study 1.

	Control	Low Distraction	High Distraction
Age (years)	20.31 (2.02)	19.77 (1.64)	19.85 (1.68)
BMI	22.64 (3.15)	21.38 (1.64)	21.70 (2.41)
Restraint (DEBQ 0.5)	2.75 (0.86)	2.57 (1.09)	2.72 (0.89)
Emotional eating (DEBQ 0-5)	3.42 (0.49)	3.46 (0.54)	3.33 (0.54)
External eating (DEBQ 0-5)	2.74 (1.26)	2.80 (0.86)	2.29 (0.95)
Hunger pre-lunch (0-100)	68.23 (12.26)	66.23 (16.22)	50.82 (1.44)
Hunger pre-snack (0-100)	30.85 (21.79)	30.15 (16.68)	30.51 (1.98)

Table 4: characteristics of the sample for Study 2.

Measure (SD)	Control	Food TV	TV
Age (years)	20.6 (4.2)	18.6 (0.8)	19.9 (4.2)

BMI	22.9 (3.0)	21 (2.6)	22.6 (4.2)
Restraint (DEBQ 0.5)	2.6 (1.0)	2.5 (1.0)	2.5 (1.0)
Disinhibition (TFEQ 0-16)	9 (2.5)	7.9 (2.0)	9 (2.1)
Hunger pre-lunch (0-100)	59.7 (21.1)	58.9 (18.1)	62.5 (14.4)
Hunger pre-snack (0-100)	47.6 (27.8)	55.3 (15.8)	50 (17.8)

Table 5 characteristics of the sample for Study 3.

Measure (SD)	Control	Celebrity imagining	Self-imagining
Sex	Female (12) male (3)	Female (14) male (1	Female (12) male (3)
Age (years)	19.3 (1.3)	19.1 (0.6)	18.9 (0.8)
BMI	22.6 (4.4)	22.6 (2)	20.9 (2.4)
Restraint (DEBQ 0.5)	1.9 (0.7)	2.0 (0.6)	2.2 (1)
Emotional eating (DEBQ 0-5)	3.2 (0.5)	3.0 (0.4)	3.3 (0.6)
External eating (DEBQ 0-5)	2.7 (0.9)	2.0 (0.8)	2.6 (1)

Hunger pre-lunch (0-100)	68.1 (5)	68.9 (16.9)	64.3 (21)
Hunger pre-snack (0-100)	46.5 (22)	36.9 (16)	34.5 (22.8)

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